Web Services for Multimedia Multicast Instant Messaging

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Abstract

Multicast service allows sending multimedia content to a group of users simultaneously. Instant messaging is a service that allows exchange of different types of messages including multimedia in close to real time. Parlay X Web Services provide an easy way for application developers to program resources of communication networks using application programming interfaces instead of complex control protocols. The paper studied deployment considerations of third party control on multicast instant messaging through Parlay X Multimedia Multicast Session Management and Audio Call interfaces in all Internet protocol based multimedia networks. Functional mapping of Web Service interface operations onto messages of communication protocols used for management of multicast sessions and provisioning of instant messaging was proposed. An approach to formal verification of the Parlay X gateway behaviour was suggested. A use case of third party control on multicast instant messaging was considered.

Keywords

Third Party Control; Internet Protocol Multimedia Subsystem; Session Management; Media Transport; Finite State Machines

Introduction

Recently, multimedia networks that use Internet protocols have provided many different information services (Lecompte, 2012), (Gruber, 2011, 2010). Users may benefit from traffic, weather and sport news. Multicast service is a unidirectional point to multipoint information service in which information is intended for a specific group of users who have service subscription. The network operator may charge both content provider and subscribers. Usually, multicast information is useful when provided on time. Instant messaging service allows sending different types of messages in close to real time (Sanchez-Esguevillas, 2013), (Ho, 2010). Messages can carry many types of data including multimedia and may be delivered in page mode or session mode. The page mode is used for transferring loosely coupled separate messages and each immediate message is an independent transaction. In session-based instant messaging, multimedia messages are part of a full dialogue between parties including session establishment with a well defined lifetime. Many useful and exciting applications may benefit the capabilities to combine multimedia multicast and instant messaging services (Cuevas, 2012), (Baladron, 2012). Session-based multicast instant messaging requires signalling session establishment before media can flow directly from peer to peer. In multimedia networks that exploit common Internet protocols, Session Initiation Protocol (SIP) (RFC 3261), (RFC 3428), and Session Description Protocol (SDP) (4566) are used for session management, while Message Session Relay Protocol (MSRP) (RFC 4975), (RFC 4776) is the actual protocol for message conveying.

Instead of programming communication protocols, Parlay X Web Services offer a simple way for network resource programmability (Gobernado, 2010). Parlay X interfaces allow external application to invoke communication capabilities in a public network using a high level abstraction that hides details of underlying network and protocol complexity. Multimedia Multicast Session Management Web Service allows a third party application to control a multicast session, its members and multimedia stream, and to obtain channel presence information (3GPP TS 29.199-20). Multimedia Messaging Web Service provides application developers with primitives to receive and send multimedia messages programmatically without specific knowledge in telecommunications (3GPP TS 29.199-5). Alternative way for provisioning third party control on messaging is through Parlay X Audio Call interfaces (3GPP TS 29.199-11). The service offers a flexible way for multimedia message delivery and the dynamic management of the media involved for the call participants. The interface is simple and convenient, not requiring the developer to manage the creation of the call. In addition to different types of messaging, the Parlay X Audio Call allows media adding or dropping in the call context.

Studies on multicasting and instant messaging (Li,

2012), (Yang, 2008), (Bryan, 2005), (Leggio, 2004) examined implementation issues related to signalling protocols while less attention is paid to third party control. Research on Web Services considers mainly interworking issues but not how third party control on multicasting and instant messaging may be implemented in managed IP-based multimedia networks.

This paper studies implementation considerations for Parlay X Multimedia Multicast Session Management Web Service and Audio Call Web Service in the context of multicast instant messaging. Deployment of Parlay X interfaces in communication networks requires implementation of a special type of application server called Parlay X gateway. The Parlay X gateway provides Parlay X interfaces facing the exterior of the network and control protocols facing the interior of the network, therefore its external behaviour exposes interface to protocol translation. The Parlay X gateway's internal behaviour is described by synchronized state machines that represent the application and protocol views on instant messaging session. A functional mapping of Parlay X interface methods onto SIP and MSRP messages is proposed. A formal approach to functional verification of Parlay X gateway internal behaviour is also suggested.

The rest of the paper is organized as follows. First of all, architectural aspects of Parlay X deployment are considered. Next, mappings of Parlay X Multimedia Multicast Session Management and Audio Call interface methods onto SIP and MSRP messages are suggested. Models representing the application and protocol views on multimedia multicast instant messaging session are proposed. Models are formally described and it is proved that they are mutually synchronized i.e. expose equivalent behaviour. At the end, a use case of application using Parlay X Multimedia Multicast Session Management and Audio Call interfaces for multicast instant messaging is described. The use case illustrates the signalling in the network.

Parlay X Interface Deployment in Multimedia Networks

Fig. 1 shows a possible deployment of Parlay X interfaces for access to multicast instant messaging functions in Internet Protocol Multimedia Subsystem (IMS). IMS is defined as an access-independent service control architecture that uses internet-based protocols. Third party Application Server hosts applications that use Parlay X interfaces. Parlay X gateway is a special type of Application Server that provides signalling connection for third party applications and allows third party control on multimedia multicast session establishment. User Equipments (UE) obtain IP connectivity either from the home or visited network. Serving Call Session Control Function (S-CSCF) is responsible for session establishment. Media server is split into two components: Media Resource Function Processor (MRFP) which provides media processing functions and Media Resource Function Control (MRFC) which represents the control part associated with the media resource management.

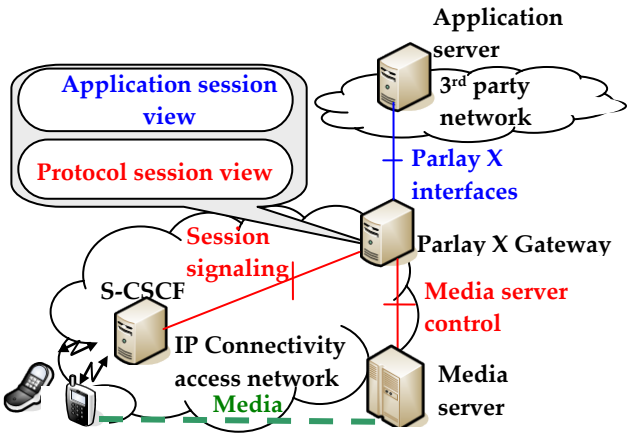

FIG. 1 DEPLOYMENT OF PARLAY X WEB SERVICE FOR MULTICAST INSTANT MESSAGING IN SIP-BASED NETWORKS

During SIP session establishment, the parameters of multimedia multicast messaging session are negotiated using SDP offer/response model. In a session-mode messaging, the MSRP, specifically designed for media transport, conveys instant messages using the session established through SIP signalling.

In an already-established multicast session with a group of participants, there has one SIP signalling relationship between Parlay X gateway and Media server for each participant. In addition to that, there is another SIP dialog between Parlay X gateway and Media server for the dedicated control channel. Commands sent on that channel will apply to the participants, whereas commands sent on just an individual dialog will apply only to the corresponding participant. When a 3rd party application sends an instant message to all participants, a dedicated SIP dialogue is used. If the 3rd party application wants to add or delete media component for participant, then the SIP dialogue that corresponds to the participant is used.

Mapping of Parlay X Interfaces onto Network Protocols

Multicast Session Management

The Multicast interface may be used by a 3rd party

application to manage multicast sessions and user participation in sessions. The application invokes createMulticastSession operation to create a multicast session using the information it provides and as a result, it receives the multicast session IP address. SIP session establishment between the Parlay X gateway and the Media server in the network is set up. The application uses a deleteMulticastSession to delete the existing multicast session. The application invokes inviteUserToJoin operation to invite users to join an existing multicast session. The SIP signalling in the network related to the use case in which a third party application invites a user (UE 1) to multicast session is shown in Fig. 2.

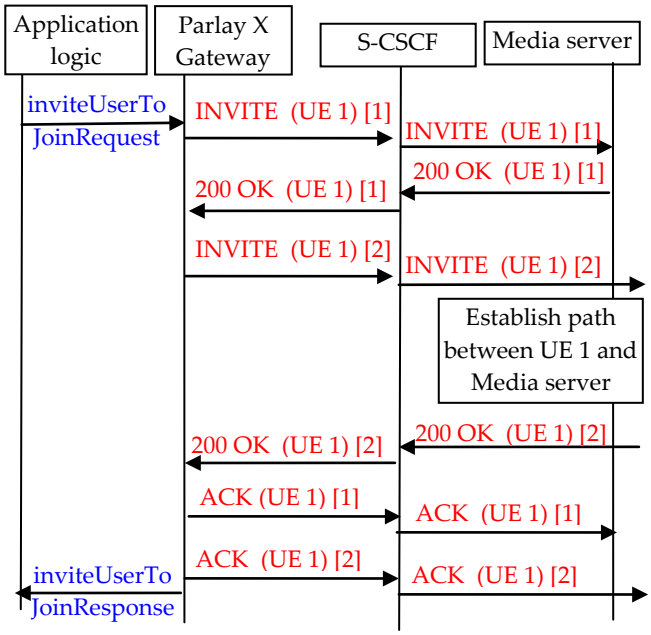

FIG. 2 THE APPLICATION INVITES A USER TO JOIN A MULTICAST SESSION

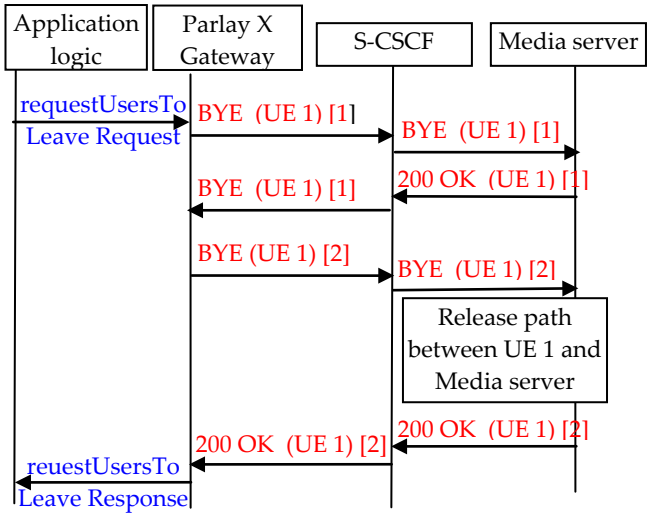

FIG. 3 THE APPLICATION REQUESTS A USER TO LEAVE A MULTICAST SESSION

The application invokes requestUsersToLeave operation to request users to leave an existing multicast session. The request initiates SIP signalling as shown in Fig. 3.

The operations querySessionParticipants, query-SessionForUser serve to retrieve information about an existing multicast session and the signalling in the network is concerned with SIP method INFO.

Operations of MulticastNotificationManager interface may be used by a 3rd party application to star and end notifications on changes associated with user participation in a multicast session. As all the SIP signalling related to the multicast session passes through the Parlay X gateway, these operations are also internal for the Parlay X gateway.

The Parlay X gateway uses the operations of MulticastNotification interface to notify the 3rd party application about changes of presence information. The notifyJoinMulticastSession operation is invoked to notify the application that a user has joined the multicast session. The message flow for this type of notification is shown in Fig. 4.

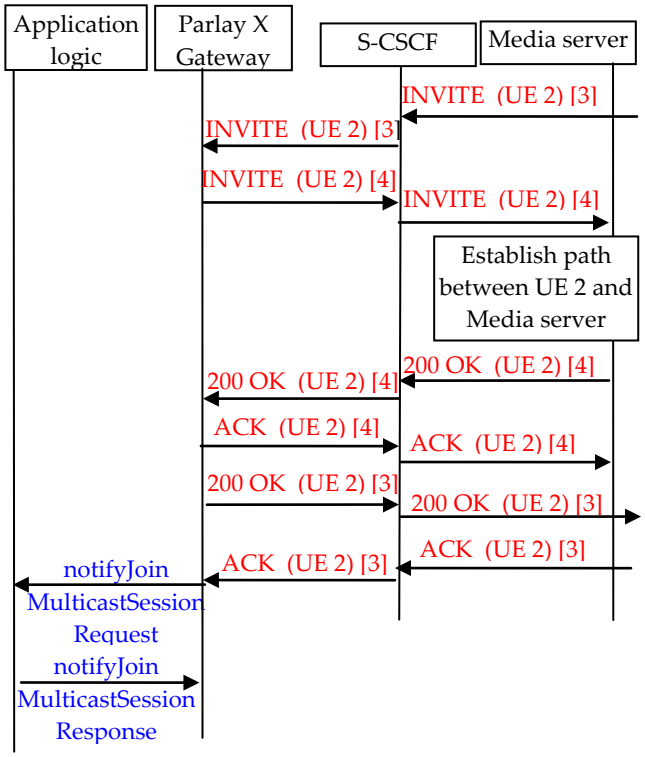

FIG. 4 THE APPLICATION IS NOTIFIED THAT A USER HAS JOINED TO A MULTICAST SESSION

When a participant leaves a multicast session, the corresponding SIP signalling takes place in the network and the Parlay X gateway invokes notifyLeaveMulticastSession in order to inform the application about the event.

Audio Call

A 3rd party application may send instant messages and

check status on sent messages. The PlayMedia interface allows playing media messages in different forms of media content. Interface operations PlayTextMessage, PlayAudioMessage, PlayVoiceXml-Message, and PlayVideoMessage may be used for this purpose.

The control data between the Parlay X gateway and the Media server may be described by two different XML-based media server control protocols that make use of SIP transport. These protocols are Media Server Control Markup Language (MSCML) (RFC 4722) and Media Server Markup Language (MSML) (RFC 5707) and they differ in the XML description but use the same SIP messages (INVITE, INFO) to carry the XML content. The XML content may look like the following:

```
< ?xml version= " 1.0 " encoding= " utf-8 " ? >
  < MediaServerControl version= " 1.0 " >
    < request >
      < play >
        < prompt >
          < audio url=
"http://messages.example.com/weather.wav " / >
        < /prompt >
      < /play >
    < /request >
  < /MediaServerControl >
```

If MSCML is used, the Parlay X gateway needs to establish a SIP dialogue with the Media server for a dedicated channel with no media. This channel is used by the Parlay X gateway to send an INFO message with the control data (instant messages to be sent).

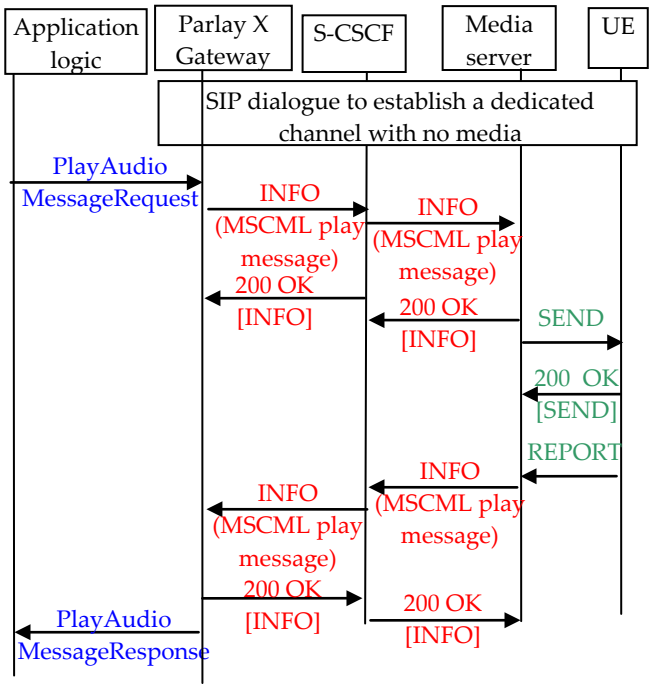

FIG. 5 THE APPLICATION SENDS AN INSTANT MESSAGE TO USERS PARTICIPATING IN A MULTICAST SESSION

The Media server uses the MSRP to send messages. The MSRP SEND request is used to deliver a complete instant message or a chunk (a portion of a complete message). The delivery of a complete instant message is confirmed using MSRP REPORT request. Alternatively, REPORT request may be used to confirm the delivery of a chunk or group of chunks received so far, and error situations.

The GetMessageStatus operation is used by the application to retrieve the message status. If the application wants to cancel message playing, it may use EndMessage operation.

The message flow when the application sends an instant messaging to a multicasting group is shown in Fig. 5.

Application and Protocol views on Multicast Session

Application View

Fig. 6 shows a simplified state machine representing the application view on multicast session. In Idle state, the multicast session is created but has no participants associated to it. When the first participant joins the session, a state transition is made to Active state in which the multicast session has one or more participants associated to it.

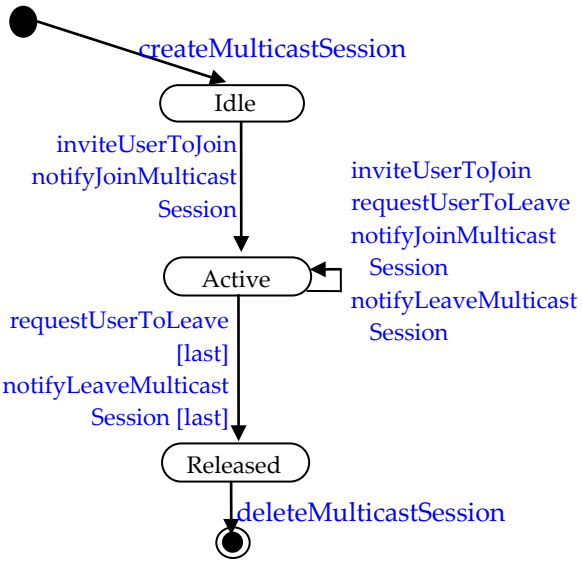

FIG. 6 APPLICATION VIEW ON MULTICAST SESSION STATE

The application may invite additional users to join the session or request a user to leave the session. In Released state, the last participant has left the session or the session was deleted.

Protocol View

A simplified protocol view on multicast session state is

shown in Fig. 7. In order to initiate a multicast session, the Parlay X gateway needs to establish a dedicated dialogue with the Media server that will be used to control the Media server. The transition to SessionEstablishment state takes place when a new user is to be joined to the session. In SessionEstablishment state, the Parlay X gateway establishes a dialogue with the Media Service with a multicast session identifier and prepares dialogue for new user. In SessionEstablished state, the Parlay X gateway has established a dialogue with the new user and the user is joined to the multicast session. In this state, it is possible for new users to join to the multicast session. The application controls the Media server using the dedicated channel in SessionEstablished state. The movement to SessionRelease state occurs when the last user is to leave the multicast session and the dialogue with the leaving participant is released. In DedicatedChannel-Release state, all the participants have left the multicast session and the dedicated dialogue for media server control has to be terminated.

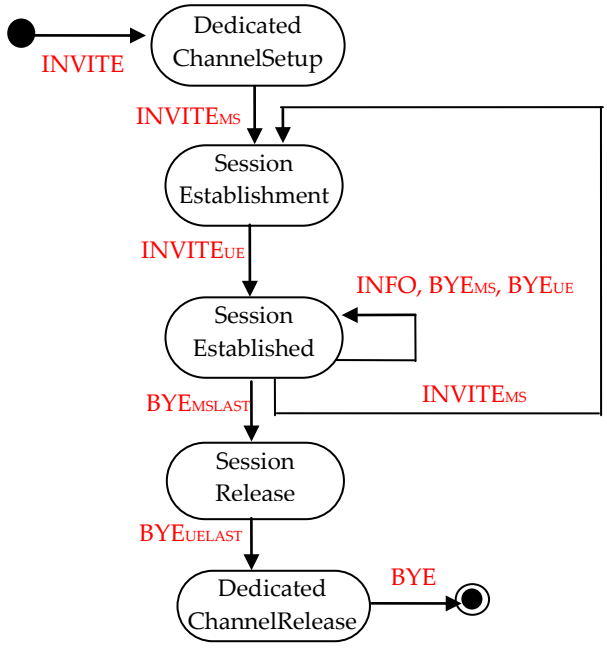

FIG. 7 PROTOCOLN VIEW ON MULTICAST SESSION STATE

An Approach to Functional Verification of Parlay X Gateway Behaviour

Both models representing the application and protocol views on multicast session may be formally described using the notion of Labelled Transition System (LTS) (Miculan, 2013), (Trcka, 2009).

By $T_{App} = (S_{App}, Act_{App}, \rightarrow_{App}, s_0')$ it is denoted as an LTS representing the Parlay X application view on multimedia multicast session where:

- S_{App} = { AppNull, Idle, Active, Released};
- Act_{App} = { createMulticastSession, inviteUserToJoin, requestUserToLeave, requestUserToLeave$_{LAST}$, notifyJoinMulticastSession, notifyLeaveMulticastSession, notifyLeaveMulticastSession$_{LAST}$, deleteMulticastSession};
- $\rightarrow_{App}$ = { AppNull createMulticastSession Idle, Idle inviteUserToJoin Active, Active inviteUserToJoin Active, Active requestUserToLeave Active, Active notifyJoinMulticastSession Active, Active notifyLeaveMulticastSession Active, Active requestUserToLeave$_{LAST}$ Released, Active notifyLeaveMulticastSession$_{LAST}$ Released, Released deleteMulticastSession AppNull};
- s_0' = { AppNull }.

By $T_{Protocol} = (S_{Protocol}, Act_{Protocol}, \rightarrow_{Protocol}, s_0'')$ it is denoted as an LTS representing an abstract protocol state machine of multimedia multicast session where:

- $S_{Protocol}$ = { Null, dedicatedChannelSetup, SessionEstablishment, SessionEstablished, SessionRelease, DedicatedChannetRelease};
- $Act_{Protocol}$ = {INVITE, INVITE$_{MS}$, INVITE$_{UE}$, INFO, BYE$_{MS}$, BYE$_{UE}$, BYE$_{MSLAST}$, BYE$_{UELAST}$, BYR};
- $\rightarrow_{Protocol}$ = { Null INVITE DedicatedChannelSetup, DedicatedChannelSetup INVITE$_{MS}$ SessionEstablishment, SessionEstablishment INVITE$_{UE}$ SessionEstablished, SessionEstablished INFO SessionEstablished, SessionEstablished BYE$_{MS}$ SessionEstablished, SessionEstablished BYE$_{UE}$ SessionEstablished, SessionEstablished INVITE$_{MS}$ SessionEstablishment, SessionEstablished BYE$_{MSLAST}$ SessionRelease SessionRelease BYE$_{UELAST}$ DedicatedChannelRelease, DedicatedChannelRelease BYE Null};
- s_0'' = { Null }.

Both labelled transition systems in the Parlay X gateway need to expose synchronized behaviour in response to inducements from applications and the network. The concept of weak bisimulation may be used to prove that the both labelled transition systems expose equivalent behaviour i.e. they are synchronized.

Proposition: The labelled transition systems T_{App} and $T_{Protocol}$ are weakly bisimilar.

Proof: To prove the bisimulation relation between two labelled transition systems, it has to be proved that there is a bisimulation relation between their states. By U, it is denoted as a relation between the states of T_{App} and $T_{Protocol}$ where U = {(AppNull, Null), (Active, SessionEstablished), (Released, DedicatedChannelRelease)}. The relation U is weakly bisimilar because of the relations presented in Table 1.

TABLE 1 BISIMULATION RELATION BETWEEN APLICATION AND PROTOCOL VIEWS ON MULTICAST SESSION

Transitions in T_{App}	**Transitions in** $T_{Protocol}$
AppNull createMulticastSession Idle, Idle inviteUserToJoin Active;	Null INVITE DedicatedChannelSetup, DedicatedChannelSetup INVITE$_{MS}$ SessionEstablishment, SessionEstablishment INVITE$_{UE}$ SessionEstablished;
Active inviteUserToJoin Active, Active requestUserToLeave Active, Active notifyJoinMulticastSession Active, Active notifyLeaveMulticastSession Active;	SessionEstablished INFO SessionEstablished, SessionEstablished BYE$_{MS}$ SessionEstablished, SessionEstablished BYE$_{UE}$ SessionEstablished, SessionEstablished INVITE$_{MS}$ SessionEstablishment; SessionEstablishment INVITE$_{UE}$ SessionEstablished;
Active requestUserToLeave$_{LAST}$ Released, Active notifyLeaveMulticastSession$_{LAST}$ Released;	SessionEstablished BYE$_{MSLAST}$ SessionRelease SessionRelease BYE$_{UELAST}$ DedicatedChannelRelease;
Released deleteMulticastSession AppNull;	DedicatedChannelRelease BYE Null;

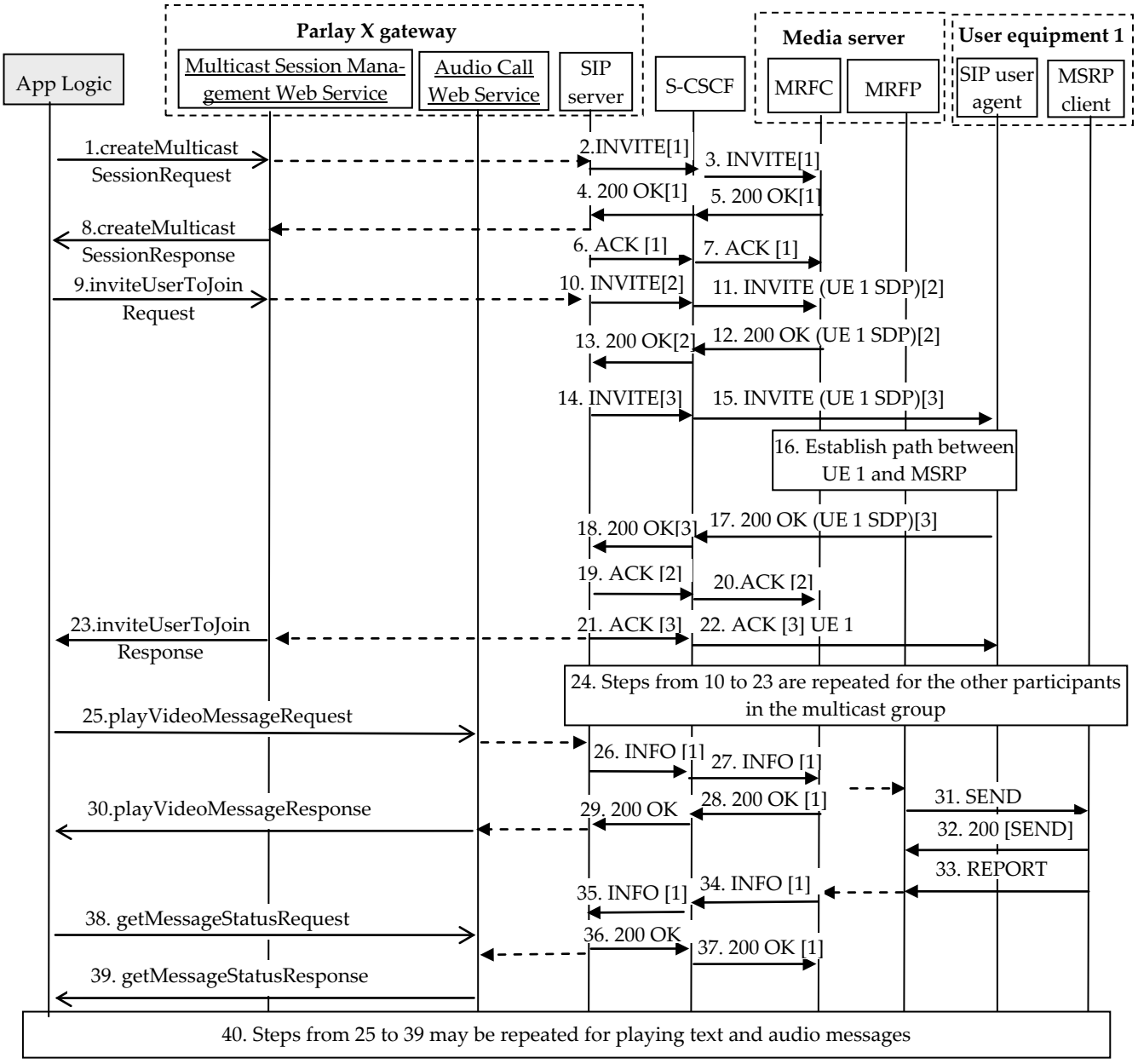

FIG. 8 AN EXAMPLE OF PARLAY X APPLICATION FOR MULTICAST INSTANT MESSAGING

Table 1 presents the bisimulation relations between the states of T_{App} and $T_{Protocol}$ indicating the transition equivalence. The proposed mapping of Parlay X Multicast Session Management interface methods onto SIP messages indicates the action's similarity. Based on the bisimulation relation between the states of T_{App} and $T_{Protocol}$, it can be stated that both labelled transition systems expose equivalent behaviour.

Use Case of Application Control on Multicast Instant Messaging

An example scenario highlights some advanced capabilities of multicast instant messaging. There is a derby between famous football teams. Because of the great interest to the derby, some of the fans could not get tickets. The network operator employs the ordinary cell broadcast service to advertise the available multicast service that provides information about the derby result immediately after the end of the derby. By subscribing to a service, those fans which could not get tickets join the corresponding multicast group. At the end of the derby, a multicast instant messaging application sends messages to the multicast group with a textual description of the derby result, the same in audio format because it is dangerous to read the text in a fast moving car and a high quality photo of the triumphing winner immediately after the end of the match. The photo can not be sent via Multimedia Messaging Service as the service has a size limitation. Therefore, the application creates a multicast session using a list of fans and sends instant messages to all participants in the session. Fig. 8 illustrates the message flow.

Conclusions

The paper studies design considerations for deployment of third party control on multicast instant messaging in all IP-based multimedia networks. External applications may access multicast session management and instant messaging functions in the network through Web services interfaces exposed by Parlay X gateway. The Parlay X gateway is responsible for conversion of interface method invocations to network control protocols and vice versa. A functional mapping of Multicast Session Management and Audio Call interface methods onto SIP and MSRP requests and responses illustrates the external Parlay X gateway behaviour. The internal behaviour is characterized by synchronized maintenance of models representing the application and protocol views on multicast sessions.

The approach is useful in testing the conformance of a black-box implementation of Parlay X gateway with respect to a specification, in the context of reactive systems.

One of the future work directions is the study on integration of open access to media services with open access to quality of service in the evolved packet networks.

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